12-2008

The Feasibility of Incorporating Sustainable Materials in the Design of Habitat for Humanity Homes

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December 7, 2008
Senior Seminar

ABSRACT *The concept of sustainable design has been one of increasing interest with regards to both personal choices and desire to reduce human impacts on the environment. This paper looks at the concept of sustainable housing design and why it is important. Particularly, it focuses on sustainable housing designs and materials that the McLean County Chapter of Habitat for Humanity can incorporate into the construction of its homes. This paper investigates three types of sustainable construction materials, flooring, cabinetry, and paints that Habitat for Humanity could incorporate into its homes.*

Introduction

For my senior seminar project, I researched sustainable materials and designs that Habitat for Humanity could incorporate into the construction of its homes. Habitat for Humanity has put aside a specified plot of land in the town of Normal, Illinois for future construction of a sustainable house. This will be the first Habitat effort focused on constructing a sustainable house in McLean County. Habitat for Humanity has already begun installing energy efficient appliances in its homes, but it does not investigate what the materials used to construct the house are made from or where they come from, and thus does not take into account the environmental impact of construction.

Habitat for Humanity is a national nonprofit organization. Habitat's goal is to eradicate inadequate housing and homelessness from the world, and to construct suitable housing for those in need. The people who work on Habitat homes are mostly volunteers with varied levels of construction ability. This makes it important that the Habitat construction process be simple, so that someone with no background in construction can help in constructing the house (Habitat for Humanity Fact Sheet).

Habitat for Humanity does not give away homes. Families are chosen to receive a Habitat house and are responsible for participating in its construction. Once the home is built, it is sold to the family at no profit and financed with reasonable loans that the family is responsible for paying (Habitat for Humanity Fact Sheet).

There are a variety of toxic substances that can be found in many non-sustainable materials. However, sustainable materials are manufactured so as to eliminate or significantly reduce the levels of toxic substances found in the final product. Incorporating sustainable materials in Habitat homes is an important topic for the Bloomington-Normal community, because people with lower incomes are more likely to live in areas or homes with more environmental hazards than wealthier individuals. It is important for the health of the Bloomington-Normal community, that Habitat for Humanity considers factors which might affect environmental health in its designs.

The goal of my research was to determine whether or not it is feasible to incorporate sustainable materials and designs at a low cost and in such a way that a volunteer can easily learn how to use the materials. Research was conducted on why incorporating sustainable material in Habitat homes is important, what sustainable materials and designs are, and what sustainable materials meet the needs of Habitat for Humanity. In order to determine which sustainable materials meet the needs of Habitat for Humanity, preliminary interviews were conducted with organizers of the McLean County chapter of Habitat for Humanity to establish a budget and the construction capabilities of the volunteers. Then, internet research was conducted to find companies that carried sustainable materials. Finally, interviews were conducted with some of the companies to figure out the cost of the sustainable materials and the installation process.

Environmental Justice

This project is important, because lower income communities are more likely to be exposed to environmental hazards than wealthier communities. The idea of environmental

injustice presents researchers with a new perspective on social inequality and public health. Many academics assert that "biases within environmental policy making and the regulatory process, combined with discriminatory market forces, result in disproportionate exposures to hazardous pollution among the poor communities of color" (Morello-Frosch et al. 2002). Environmental injustice raises the difficult question of whether differences in exposure levels to environmental hazards may play a vital role in detectable patterns of unequal health conditions in the poor and people of color (Morello-Frosch et al. 2002).

The results of research on disparities in toxic exposures between different race and class groups vary. However, most of the data indicate a pattern of unequal exposures to toxins and an increase in linked health risks (negative health effects potentially caused by exposures to toxins) among poor areas and non-white communities. Sometimes the racial discrepancies can even be seen across economic and social classes (Morello-Frosch et al. 2002). Even so, linking the presence of environmental contaminants with potentially adverse health effects is a continuous challenge, especially in communities where people are constantly exposed to complex chemical cocktails (Institute of Medicine 1999). With a couple of exceptions, researchers investigating environmental inequities have restricted their research to assessing differences in the location of contamination sources between low-income and wealthier communities and have spent less time assessing the distribution of health risks due to different levels of exposure between low-income and wealthier communities. Of particular concern has been the need to go beyond the "chemical-by-chemical" or "facility-by-facility" analysis toward a "cumulative exposure approach" which takes into consideration the exposure of diverse populations and integrates ideas of race and class into evaluations of community susceptibility to contaminants (Morello-Frosch et al. 2002).

It is important, when constructing a home or community that one considers the health of everyone involved. This not only includes low-income families, but also the construction workers, the manufacturers of the materials, and the health of the surrounding ecosystem. According to the Rio Declaration on Environment and Development, "Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature" (1992). By incorporating sustainable materials and designs into the construction of its homes, Habitat for Humanity would not only be helping to reduce the disparities in toxic exposure levels between wealthy communities and low-income communities, but also providing low-income families with the means for a "healthy and productive life in harmony with nature" (Rio Declaration 1992).

Health effects of toxic chemicals found in construction materials

Since lower-income communities already receive a disproportionate share of environmental contaminants, it is particularly important to ensure that the building materials used in their homes do not contain toxic substances. There are a variety of toxic substances that can be found in construction materials, for example, lead, perfluorochemicals (PFCs), phthalates, and polybrominated diphenyl ethers (PBDEs). A summary table of the health effects of exposure to toxins in building materials can be found in Table 1 in the Appendix (Pearson et. al. 2002).

Quite a few studies have documented unusually high levels of the above toxins in the bodies of individuals of varying ages. One particular study chose to focus on a family and

monitor the amounts of hazardous chemicals in the bodies of each family member. The family consisted of two parents and two children ages 5 years and 18 months. The tests revealed that the 18 month-old and the 5 year-old child had chemical exposure levels up to seven times those of their parents (Miller 2007). The 18 month-old in particular had two to three times the concentration of a flame retardant present in his body known to cause thyroid dysfunction in lab rats. The major industrial chemicals used in the manufacture of flame retardants are PBDEs, which have been found to cause neurological damage in rats. Dr. Leo Trasande of the Center for Children's Health and Environment at the Mount Sinai Medical Center in New York City suggests that industrial toxins could be leading to more childhood disease and disorder (Miller 2007).

In general, children up to six years of age are most at risk, because their organs are still developing. Children depend on their environment more than adults, because their bodies absorb more nutrients (good and bad) from their surrounding environment than adults. Studies on the health effects of PBDEs have only just begun. However, Sweden banned PBDEs in 1998 and the European Union did the same in 2004. Nevertheless, the United States has not banned PBDEs and these substances can still be found in electrical equipment, construction material, mattresses and textiles. Another chemical, phthalates, which have been associated with reproductive defects, obesity, and early puberty, can be found in paint and plastic packaging (Miller 2007).

Since children generally absorb more toxins than adults and members of low-income communities are more susceptible to exposure to toxic substances, it follows that children in low-income communities absorb greater levels or toxic substances than low-income adults and members of wealthier communities. Since Habitat for Humanity provides housing for families, it is important that it factors in environmental health when considering which construction materials to purchase.

Sustainable Material and Design Choices

Despite all the toxic chemicals that can be found in building materials, there are alternative choices. Sustainable building incorporates a number of different strategies during the design, construction, and operation of the building with benefits to the home owner including: reduced long-term maintenance costs, conservation of energy, and improved health of the homeowner. Moreover, sustainable construction materials are made of renewable, rather than nonrenewable resources and thus provide environmental benefits as well. Table 2 in the Appendix presents the characteristics of sustainable materials and designs (Dick 2007).

One of the biggest factors that has hindered applying the above guidelines to construction is that there are many green design myths, including: "It's too expensive," "I can't get products where I live, so why bother?" I don't want to live in a strawbale house," and "Solar is ugly" (Johnston 2004). It is true that some sustainable materials cost more, but many cost less. Quite a few builders have found that the biggest cost is in the learning curve, not in the execution of the construction process. Many products are becoming more available and more affordable as manufacturers design new products to meet the "green demand" (Johnston 2004). For example, paints that are low in volatile organic compounds (VOCs) are now found in the major product lines of manufacturers.

It is all well and good that these materials exist, but finding sustainable products that are both inexpensive and have a simple installation process will facilitate Habitat for Humanity's desire to incorporate sustainable materials into the construction of its homes. Throughout this research project, I worked closely with Rebecca Rossi, who works with Habitat for Humanity and is project manager for the first Habitat for Humanity green house to be built in Bloomington-Normal, Illinois in 2009-2010. We agreed that using recycled materials was preferable to using newly designed materials. Not only do recycled materials reduce the amount of waste that gets dumped into a landfill, but they are generally less expensive. We also agreed that locally manufactured sustainable materials were preferred. Not only will the shipping cost be reduced, but the ecological footprint (the total area of productive ecosystems required to support a population, in this case the carbon emissions released during the transportation of the products will be reduced (Cain et al. 2008). Overall, choosing a local business (within close proximity to Bloomington-Normal) is preferred over a non-local business. After discussions with Ms. Rossi, I decided to focus my research on flooring materials, cabinets, and paints.

The decision to focus on sustainable flooring materials, cabinets, and paints came about through a mutual concern between Ms. Rossi and me about indoor air quality. According to the U.S. Environmental Protection Agency (EPA), indoor air is usually 2-5 times more polluted than outdoor air, because of the presence of asthma-inducing agents such as mold, toxic chemicals in carpets, paints, and other synthetic materials (Schmidt 2008). How can non-sustainable flooring materials, cabinets, and paints negatively affect indoor air quality?

According to Ms. Rossi, Habitat for Humanity currently uses vinyl flooring. Vinyl is derived from petroleum and salt to initially make ethylene. The ethylene is then combined with elemental chlorine (Cl_2) to produce ethylene dichloride. The ethylene dichloride is transformed to a gas, vinyl chloride monomer (VCM). Through polymerization, VCM is converted to vinyl resin. Vinyl resin is a powder and must be combined with different chemicals so that it can be used to make flooring (About Vinyl & PVC). Depending on the concentration, exposure to vinyl chloride can cause central nervous system effects, loss of consciousness, or death (Fries 2007). Since vinyl chloride is a gas at room temperature, people are most likely to be exposed to it by breathing it in (Agency for Toxic Substances and Disease Regulation 2004). There is evidence indicating that vinyl chloride can get into food stored in materials containing polyvinyl chloride. Further more, if vinyl chloride contacts your skin, tiny amounts can pass through the skin and enter your body (Agency for Toxic Substances and Disease Regulation 2004). Refer back to the case study by Miller (2007) about children's bodies containing more toxins than adults. Especially think about the 18 month old child who had the highest levels of toxins in his/her body. Children in particular spend much of their childhood near the ground, whether they are crawling, playing with toys, or even just sitting. An 18 month old child, for example, crawls in order to get around. His/her hands, feet, and legs (assuming that he/she is crawling on a vinyl floor) can absorb vinyl chloride at a higher rate than adults. This means that children exposed to vinyl chloride will have an increased risk of developing central nervous system problems, loss of consciousness, or even early death. Replacing vinyl flooring with a sustainable option will improve the indoor air quality and will hopefully protect children and adults from experiencing negative side effects as a result of exposure to vinyl chloride. Another important aspect of flooring is that the installation processes are fairly simple or the same from product to product.

Indoor air quality is a concern in many households. From formaldehyde in furniture to dangerous chemicals in electrical equipment and even lead in vinyl products (see Table 1), indoor air quality cannot be taken for granted (McDilda 2007). Formaldehyde is a flammable, strong-smelling gas that is used in the manufacture of many building materials. Formaldehyde can be found in many products, such as wood cabinets. When exposed to formaldehyde, many individuals can experience numerous short-term health effects. Formaldehyde is considered a human carcinogen (cancer-causing agent) by the International Agency for Research on Caner and as a probable carcinogen by the U.S. Environmental Protection Agency. Many studies have suggested a link between formaldehyde exposure and cancers of the nasal sinuses, nasopharynx, brain, and possible leukemia (Formaldehyde and Cancer: Questions and Answers 2004). Not only is formaldehyde a carcinogen, but it has also been linked to numerous short-term health effects when formaldehyde levels exceed .1 ppm. Some short-term side effects of formaldehyde are watery eyes, burning sensations of the yes, nose, and throat, coughing, wheezing, nausea, and skin irritation (formaldehyde and Cancer: Questions and Answers 2004).

According to a 1997 report by the U.S. Consumer Product Safety Commission, formaldehyde is commonly present in both indoor and outdoor air at low levels (less than .03 ppm). Products containing formaldehyde can release formaldehyde gas into the air which can be breathed in by people. During the interview with Ms. Rossi, she expressed a concern that the cabinets Habitat for Humanity is currently using contain formaldehyde. It is important for the health of the future home owner, that Habitat for Humanity use no formaldehyde cabinets.

The third construction material that I decided to research is sustainable paint. Common substances found in non-sustainable paints are volatile organic compounds (VOCs). VOCs are emitted as gases from certain solids or liquids and tend to be higher indoors (up to ten times higher) than outdoors. VOCs have been linked with many short-term and long-term adverse health affects such as eye, nose and throat irritation; headaches, loss of coordination, nausea; damage to liver, kidney, and central nervous system. Some VOCs can cause cancer in animals and are suspected of causing cancer in humans. VOCs are gases and can enter the human body through respiration (An Introduction to Indoor Air Quality 2008). Introducing sustainable paint is not only important for enhancing the indoor air quality, but it is also easy to install. The installation process for all paint is the same. It would be very easy for a Habitat volunteer to learn how to use it.

After narrowing down my research, the next step in the research process involved internet research on existing sustainable construction materials and designs. Processes involved in the production of sustainable materials were investigated and a comparison chart of the pros and cons of each material was constructed. Internet research alone did not provide all of the answers, so construction supply companies were interviews. Interviews started with local construction supply companies. If sustainable materials could not be found locally, interviews were conducted with non-local companies starting with those closest to Bloomington-Normal and ending with companies furthest from Bloomington-Normal. During interviews, knowledge was gained on what products the companies actually carry, the cost of the products, the manufacturing process, and the shipping distance.

These interviews provided information about the installation processes for each material in order to determine if it is within the construction capabilities of Habitat volunteers. As companies were interviewed, a chart was developed comparing the location of the company, the products (flooring materials, cabinets, paint), the sustainable features of products, features of the products that negatively impact the environment, the cost of the product, the installation process, and the installation cost. The data gathered have been presented to Ms. Rossi who will ultimately choose which materials are worth investing in for Habitat for Humanity.

Results

Sustainable Carpeting

Initially I conducted internet research on sustainable flooring. The first company website that I investigated was Mohawk Industries. Mohawk is one of the world's largest flooring manufacturers and distributors and is a leading producer of yarn, ceramic tile, area rugs, and bath mats. Mohawk is headquartered in Calhoun, Georgia but has many manufacturing facilities throughout the United States (About Mohawk 2008).

Mohawk has created two brands of sustainable carpets. The first brand, SmartStrand® with DuPont™ Sorona® renewable sourced polymer, contains ingredients made from corn sugar (37% renewable resource). These renewable materials replace materials that were originally derived from petroleum (a limited resource). "Every seven yards of SmartStrand® with DuPont™ Sorona® renewable sourced polymer saves the energy equivalent of one gallon of gasoline" (Green Carpeting 2008). According to the manufacturer, SmartStrand® with DuPont™ Sorona® renewably sourced polymer reduces our ecological footprint and is durable and stain resistant (Green Carpeting 2008).

Mohawk's second brand of sustainable carpeting is EverStrand™. Everstrand™ is manufactured from recycled plastic beverage bottles. The recycled plastic bottles can be processed into fibers that are superior to lower-grade virgin synthetic fibers used in making other types of carpet. Mohawk recycled more than three billion plastic bottles per year (14,000 bottles per minute) in order to manufacture EverStrand™ carpet (Green Carpeting 2008).

Mohawk Industries not only produces sustainable carpet, but it also produces sustainable laminate flooring. Mohawk's laminate flooring is manufactured in the United States and is made of 75% pre-consumer recycled content. According to the website, Mohawk keeps 680 million pounds of material out of landfills. In Mohawk's facilities, only renewable, fast growing southern pine is used. Also, Mohawk suppliers plant six times more trees than they harvest, saving the unnecessary destruction of additional trees. On top of producing laminate from pre-consumer recycled content, the Mohawk U.S. laminate facility located in Thomasville, North Carolina, uses sawdust waste created during production as fuel and any leftover wood waste as biomass fuel for process heating (Laminate Flooring: Finding New Uses for Our Waste 2008).

After doing preliminary research on Mohawk Industries and its subsidiaries, I discovered that Carpet Weaver's Inc. located in Bloomington, IL carries Mohawk products. I met with the store owners to discuss sustainable flooring options for Habitat for Humanity. The store owners

provided me with the website for the Dal-Tile Corporation which is a subsidiary of Mohawk Industries. This website lists the different types of tile (porcelain, glazed, mosaic, quarry/saltillo, and natural stone and slabs), how much of the tile is made from pre-consumer waste, how much of the tile is made from post-consumer waste, where the tile is manufactured, and relative price of the tile. Pre-consumer waste refers to waste discarded before it was ready for consumer use. Post-consumer waste refers to waste that is discarded after someone uses it (R. 2007).

The Dal-Tile Corporation, a subsidiary of Mohawk Industries, manufactures, distributes and markets high-quality tile (Corporate Information2008). According to the website, Dal-Tile is dedicated to incorporating environmentally friendly materials, processes, and products throughout its warehouses, factories, offices, employees, customers, and vendors. In order to manufacture tile, Dal-Tile minimizes the use of virgin raw materials and maximizes the reuse of scrap tile generated during the manufacturing process. Manufacturing operations performed by Dal-Tile used natural gas as an energy source instead of fuel oils or coal. This minimizes the carbon emissions produced during the manufacturing process (Healthy Planet 2008).

The above information is described in Tables 3 and 4 which can be found in the Appendix. Not all of the types of tile are included. Only the tile that is made from a high amount of recycled content, is manufactured in the U.S., and/or has a relatively low price is included.

Sustainable Flooring Discussion

Sustainable Carpet

As mentioned above, Mohawk Industries provides two types of sustainable carpet, SmartStrand® with DuPont™ Sorona® renewably sourced polymer and EverStrand™. However, which one is the best choice for Habitat for Humanity? There are four main design features that Rebecca Rossi requested to be taken into consideration: price, installation process, percentage made from recycled content, and distance manufactured. Based on these criteria, I believe that the Everstrand™ is the best choice for Habitat for Humanity. Though information on price, installation process, and distance were not available, information on recycled content was. Unlike SmartStrand® with DuPont™ Sorona® renewably sourced polymer, EverStrand™ is made from recycled plastic bottles. Since I was unable to obtain information on the other three criteria, I had to base my decision on recycled content level.

Sustainable Tile

It is a lot harder to determine which sustainable tile is the best choice for Habitat for Humanity, because there are so many options. Different tiles are going to be better suited for different rooms in the Habitat house. For each type of tile, I have analyzed which one best fits Ms. Rossi's specifications.

In looking at Table 3 and Table 4, the best options are either Village Bend or Gold Rush for both porcelain tile and sustainable glazed ceramic tile. These two types of tile are made from 50.9% pre-consumer waste and are manufactured in the U.S. Compared to the manufacturing locations of the other types of Porcelain tile (all abroad), Muskogee, Oklahoma is relatively close

to Illinois. The price of these two tiles is also relatively lower than the price of the other porcelain tiles.

Sustainable Cabinets

It has been much harder to find sustainable cabinet manufacturers, because usually cabinets do not count towards points in environmental certification programs. However, I was able to find two sustainable cabinet manufacturers. The first company I interviewed was Steelskin which is based out of Chicago. The second company I investigated was Omega Cabinetry which has two manufacturing facilities, one in Waterloo, Iowa and the other in Clinton, Tennessee.

Steelskin manufactures two types of sustainable cabinets: ECOSKIN-SS and ECOSKIN-EV. The ECOSKIN-EV is a combination of Steelskin's no-added-formaldehyde and PVC cabinet box. ECOSKIN-EV is different from ECOSKIN-SS in that it also has eco-friendly engineered veneer doors and drawers. The veneers are Greenguard certified for indoor air quality and are attached to a no-added-formaldehyde core using thermo adhesive technology (a very clean, voc & formaldehyde free technology). Greenguard certification is a program which evaluates the sustainability of products based on many criteria such as low chemical and particle emissions (GREENGUARD Indoor Air Quality Certified 2008). Also, Steelskin uses veneers manufactured in the U.S. Steelskin is not deforesting wood species in their native environments (ECOSKIN-EV Environmentally committed… 2008). (For more information on Greengaurd certification go to this website http://www.greenguard.org/Default.aspx?tabid=109.)

ECOSKIN-SS is a budget conscious alternative in sustainable cabinetry. The ECOSKIN-SS has no added formaldehyde or PVC, and the ECOSKIN-SS is FSC certified. FSC stand for the Forest Stewardship Council. FSC (Forest Stewardship Council) certified wood products are from a sustainable-managed forest. Certification is based on ten different sustainability categories (Standards & Policies 1996). (For more information on the criteria for FSC certification see http://www.fscus.org/standards_criteria/).

I interviewed a representative from Steelskin via email and asked about the cost of each type of cabinet. The individual who responded said that if Habitat for Humanity were to assemble the cabinets themselves, Steelskin could reduce the price by 20%. Bill McConnell, the executive director of the McLean County chapter of Habitat for Humanity stated that Habitat would be willing to assemble the cabinets themselves.

The second company I investigated was Omega Cabinetry. Omega Cabinetry has earned certification in the Environmental Stewardship Program administered by the Kitchen Cabinet Manufacturer's Association (KCMA). The Environmental Stewardship Program was established in 2006 and awards annual certification to manufacturers who meet specific environmental criteria. The criteria were designed to promote the sustainability of natural resources, reduce waste, and reward companies who are reducing environmental impacts. (See Table 7 in the Appendix for information on the criteria.) The Environmental Stewardship Program provides kitchen cabinet manufacturers with a viable method to measure their environmental management practices against an industry standard (Omega Earns KCMA Environmental Stewardship

Certification 2008). In order to be certified through the Environmental Stewardship Program, manufacturers must show that they are using low formaldehyde raw materials (Omega Earns KCMA Environmental Stewardship Certification 2008).

Discussion: Sustainable Cabinets

It has been particularly difficult to determine which sustainable cabinets meet the needs of Habitat for Humanity. In my opinion the Steelskin ECOSKIN-SS is the best option for Habitat for Humanity. First, Steelskin manufacturers are located closer to Bloomington-Normal than Omega manufacturers. As mentioned earlier, ECOSKIN-SS is a budget conscious version of Steelskin's sustainable cabinetry. It is less expensive than the ECOSKIN-EV. I was not able to obtain prices from either Steelskin or Omega, but Steelskin is willing to reduce the price of the cabinets by 20% if Habitat for Humanity assembles them. According to the representative from Steelskin, the ECOSKIN-SS cabinets are fairly easy to assemble and install. I was unable to attain information on the installation process for Omega cabinets, but if Habitat for Humanity chose Omega, it would also have to purchase countertops. Both the ECOSKIN-SS and ECOSKIN-EV come with countertops, whereas with Omega, countertops would have to be ordered separately. Ordering the countertops separately would increase the price of the cabinets and increase the difficulty of installation.

I found some sustainable countertop options on Omega's website. However, for the most part they are only made from 6-13% pre-consumer waste. Also, the manufacturing process for the countertops is very energy intensive and releases a lot of carbon emissions. While Steelskin cabinets are made from steel (which is also energy intensive and releases a lot of carbon), they are going to be less expensive than Omega Cabinets.

Throughout my research I have come across many environmental certification programs. I have investigated all of the certification programs mentioned in this paper in order to determine if they are accepted by recognized environmental agencies. Steelskin is FSC and Greenguard certified. FSC certification and Greenguard certification are both widely used and accepted by many environmental organizations. However, The Environmental Stewardship Program, which certified Omega, is not recognized by any of the green home standards (KCMA Environmental Stewardship Program Frequently Asked Questions).

Sustainable Paints

The last sustainable construction material I investigated was sustainable paint and primer. I investigated two manufacturers, Mab paints and Diamond Vogel. Mab Paints manufacturers are located in Pennsylvania and offer a variety of sustainable options. However, I am only going to focus on one type of primer and one type of paint. (Mab Paints' other sustainable paint options can be found in Table 5 in the Appendix). Mab Paints manufactures Enviro Pure Primer. Enviro Pure Primer is Green Seal Certified, produces low odor, complies with all GS-11 requirements, and has no VOCs. Mab Paints also manufactures Enviro Pure paint. Enviro Pure paint comes in three different finishes, flat, semi-gloss, and eggshell. Like the Enviro Pure primer, Enviro Pure paint is Green Seal approved and certified, complies with all GS-11 requirements, does not

contain VOCs, and is low odor (Enviro-Pure Latex Interior Finishes 2008). (For information on Green Seal Certification see http://www.greenseal.org/)

The second manufacturer I investigated was Diamond Vogel Paint. Diamond Vogel is Family owned and located in Orange City, Iowa. Diamond Vogel manufactures a variety of low VOC paints and sustainable paints. According to the Web site, Diamond Vogel tries to reduce energy consumption and conserves natural materials throughout the manufacturing process by recycling by products. Diamond Vogel manufactures Health Kote Zero VOC Interior PVA primer/sealer. The Health Kote Zero VOC Interior PVA primer/sealer has 0 g/L VOC. Diamond Vogel also manufactures Health Kote Zero VOC Interior paint. Like the name suggests, the Health Kote Zero VOC Interior Paint has 0 g/L VOC and comes in two finishes eggshell, and semi-gloss. Diamond Vogel's sustainable paint meets the requirements for LEED certification (See Table 6 for a listing of Diamond Vogel's sustainable paint options and see http://www.usgbc.org/DisplayPage.aspx?CategoryID=19 for information on LEED certification).

Discussion: Paint

In my opinion, Diamond Vogel paint/primer is the best option for Habitat for Humanity. Both Diamond Vogel and Mab Paints offer a variety of sustainable paint and primer options. They both have 0 VOC products as well. However, Diamond Vogel manufacturers are located closer to Bloomington-Normal than Mab Paints manufacturers.

Conclusion

In light of issues related to environmental justice and injustice issues, it is important to design homes and buildings with sustainability in mind. It is especially important to ensure that people in low-income areas have equal opportunity to take advantage of products that are not linked to adverse health effects, because generally people who live in low-income areas are subjected to more environmental hazards than people who live in wealthier communities. The amount of research on environmental justice issues and why this is important is plenty. However, there is a lack of research on the use of sustainable materials in construction, especially as related to the poor.

In conclusion, the best product options for Habitat for Humanity are Mohawk's EverStrand carpet, Dal-Tile's Village Bend or Gold Rush tile, Steelskin's ECOSKIN-SS, and Diamond Vogel Paint. There are many areas for further study. First, more sustainable construction materials need to be researched for Habitat for Humanity. Second, it is important to do follow up research on the companies I researched. The field of sustainable construction is fairly new. New sustainable products and designs are becoming available every day. While the products I investigated may be the best for Habitat for Humanity now, they may not be in the future. For example, Steelskin cabinets just began manufacturing a new line of cabinets called ECO-URBAN. It is a very new cabinet line and not much is known about it. It will be important that Habitat for Humanity continues to research sustainable designs and materials in the future, because new and better sustainable technologies are being produced everyday.

Appendix

Table 1: Exposure routes and the health effects of chemicals found in construction materials

Toxin	Exposure Routes	Health effects
Lead	Lead-based paint in homes; household dust, vinyl products (such as vinyl flooring), tap water	Brain and nervous system problems, birth defects and developmental delays
PFC	Couches, carpets	Cancer, birth defects and developmental delays, endocrine system problems
Phthalates	Paint, soft plastic, packaging	Hormone activity problems, reproduction and fertility problems, birth defects and developmental delays
PBDEs	Foam furniture, carpet padding, contaminated house dust	Reproduction and fertility problems, brain and nervous system problems

Table 2 Characteristics and environmental benefits of sustainable materials and designs.

Characteristic	Environmental benefit
Recycled Content	Less energy used in manufacturing process; less waste entering landfills; reduced consumption of natural resources
Materials harvested from sustainably managed sources	Natural, plentiful, and renewable
Resource efficient manufacturing process	Energy consumption minimized; waste reduced; and greenhouse gases (carbon dioxide, methane) reduced
Locally available	Energy and resources saved in transportation to construction site

Durable: materials that are long lasting	Waste reduced; consumption of resources reduced

Table 3 Sustainable Porcelain Tile from Dal-Tile Corporation (Porcelain 2008)

Name	Pre-consumer	Post-consumer	Manufacture location	Relative price
Metro leather	40.00%	0	>500mi	Medium/High
Keystone Shapes	22.00-24.30%	0	Olean, NY	Medium
Keystones	22.00-24.30%	0	Olean, NY	Low/Medium/High
Metal fusion	52.60%	0	>500mi	High
Caprricio	40.00%	0	>500mi	Medium/High
Gold Rush	50.90%	0	Muskogee, OK	Low/Medium
Villa Valleta	50.90%	0	Muskogee, OK	Medium/High
Castle De Verre	50.90%	0	Muskogee, OK	Medium
Pietre Vecchie	52.60%	0	>500mi	Medium/High
Canaletto	50.90%	0	Muskogee, OK	Medium/High
Village Bend	50.90%	0	Muskogee, OK	Low/Medium
Passaggio	50.90%	0	Muskogee, OK	Medium

Table 4 Sustainable Glazed Ceramic Tile (Glazed floor/wall 2008)

Name	Pre-consumer	Post-consumer	Manufacture Location	Relative price
Brixton	40.10%	0	Monterrey, MX	Low/Medium
Modern Dimensions	45.50%	0	Dallas, Tx	Medium High

Gold Rush	50.90%	0	Muskogee, OK	Low/Medium
Villa Valleta	50.90%	0	Muskogee, OK	Medium/High
Pietre Vecchie	52.60%	0	Imported >500mi	Medium
Village Bend	50.90%	0	Muskogee, OK	Low/Medium
Ridgeview	40.10%	0	Monterrey, MX	Low
Natural Hues	21%	0	Imported >500mi	Medium/High
Brancacci	35.80%	0	Monterrey, MX	Medium
Travata	50.90%	0	Muskogee, OK	Medium
Sierra	40.10%	0	Monterrey, MX	Low

Table 5 Mab sustainable paint products.

Type of Product	Name	Environmental Certification	Product Attributes
Primer	Enivro Pure Primer	Green Seal	Low Odor, zero VOC
Primer	Master Painters Pro 30 Latex Wall Primer	Not Certified	Seals drywall
Primer	Block Kote 1000	Not Certified	Alkali Resistant, Fills pores and cracks
Paint	Enviro Pure Latex Flat	Green Seal	Low Odor, zero VOC
Paint	Cover Quick Flat	Not Certified	Quick drying, easy application
Paint	Enviro Pure Latex Eggshell	Green Seal	Low Odor, zero VOC
Paint	Eclipse Acrylic Eggshell	Not Certified	Low odor
Paint	Design Accents Eggshell Interior/Exterior	Not Certified	Good weathering durability
Paint	Rich Lux Architectural Alkyd Enamel	Not Certified	Low Odor
Paint	Fresh Kote	Not Certified	Durable, quick drying
Paint	Master Painters Pro 30 Latex Eggshell	Not Certified	Quick drying
Paint	Envir Pure Latex Eggshell	Green Seal	Low Odor, zero VOC
Paint	Fresh Kote Latex Semi-Gloss	Not Certified	Low VOC

Table 6 Diamond Vogel sustainable paint products.

Finish	Primers & Topcoats	Prodcut Code	VOC concentration
Primer	Health Kote Interior PVA Zero VOC Primer/Sealer	DU-1590	0g/L
Primer	Interior PVA Primer/Surfacer	DU-1520	58g/L
Primer	Interior PVA Primer/Sealer	DU-1507	83g/L

Flat	Health Kote Interior Latex Flat	DF-Series	0g/L
Flat	Vantage Plus Interior Latex Flat Enamel	DF-Series	<50g/L
Eggshell	Health Kote Interior Latex Eggshell	DE-Series	0g/L
Eggshell	Pro Plus Interior Latex Eggshell Enamel	DE-Series	89g/L
Eggshell	Vantage Plus Interior Latex Eggshell Enamel	DE-Series	100g/L
Semi-Gloss	Health Kote Interior Latex Semi-Gloss	DS-Series	0g/L
Semi-Gloss	Pro Plus Interior Latex Semi-Gloss Enamel	DS-Series	66g/L
Gloss	Pro Plus Interior Latex Gloss Enamel	DH-Series	60g/L
Finish	Primers & Topcoats	Product Code	VOC level
Primer	Health Kote Interior PVA Zero VOC Primer/Sealer	DU-1590	0g/L
Primer	Interior PVA Primer/Surfacer	DU-1520	58g/L
Primer	Interior PVA Primer/Sealer	DU-1507	83g/L
Flat	Health Kote Interior Latex Flat	DF-Series	0g/L
Flat	Vantage Plus Interior Latex Flat Enamel	DF-Series	<50g/L
Eggshell	Health Kote Interior Latex Eggshell	DE-Series	0g/L
Eggshell	Pro Plus Interior Latex Eggshell Enamel	DE-Series	89g/L
Eggshell	Vantage Plus Interior Latex Eggshell Enamel	DE-Series	100g/L
Semi-Gloss	Health Kote Interior Latex Semi-Gloss	DS-Series	0g/L
Semi-Gloss	Pro Plus Interior Latex Semi-Gloss Enamel	DS-Series	66g/L
Gloss	Pro Plus Interior Latex Gloss Enamel	DH-Series	60 g/L

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